Mulch Treatment with Mulch Planter and its Effects on Maize Production

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Summary

A study was done to develop management and protection of soil and water. The effect of rice husk as mulch was examined for maize production. The seeds of maize were planted in two different depths (4 and 6 cm) and the husk of rice was injected in different conditions (lateral part of row and sub row) by a mulch planter in a farm of Shahrekord. Different mulches were placed in soil (without mulch, 200, and 300 g per a meter of length). A factorial design based on complete randomized block was performed. Indices of plant height, weight of ear, diameter of ear, length of ear, weight of ear sheath, height growth rate of plant, and seed numbers in each ear were measured. Results showed that differences were significant in the indices of plant height, height growth rate of plant, and seed numbers in each ear. In the other indices were not seen significant differences. The results also showed that there was no significant difference in the weight of ear and ear sheath. The depth of 6 cm, 300 g mulch per a meter, and injected mulch in the lateral part of row enhanced growth of plant height and seed numbers in each ear.

Key words

maize, rice husk, seed depth

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Introduction

Soil protection and prevention of soil erosion along with using water in the best way are important in agriculture. In agricultural engineering, application of machines and equipments for decreasing tillage process and adding crop residues to soil as mulch to increase the capacity of water preservation in soil and decreasing erosion have been proved. Li (1996) applied a subsoiler and a row planter with straw mulching technique between rows. Results showed improvement of water supply, keeping moisture and soil fertility. Anikwe (2000) studied the effect of rice husk dust (burnt and unburnt) on maize yield, plant height, and soil physical properties and reported that there was not significant difference between burnt and unburnt rice husk. Sharma et al. (2009) studied the influence of tillage and mulching practices on crop productivity, economy and soil properties of maize –wheat system under rain fed situation. Three different mulch materials (straw, polyethylene and soil mulch) were used. Result showed that minimum tillage in conjunction with polyethylene mulch or straw mulch was economically profitable and improved crop production and soil quality. Khan et al. (2011) studied the impact of different mulches (wheat straw, saw dust, polyethylene (white), polyethylene (black), newspaper, and Primextra Gold 720SC at 1.0 L ha^{-1}) on the yield of maize. The maximum grain yield was recorded for Primextra Gold 720SC. Sharma et al. (2011) compared four mulch levels (control, polythene, straw, and soil) and reported that Polythene mulch and straw mulch were almost equally valuable in maize and wheat sequence. Uwah and Iwo (2011) evaluated the effectiveness of organic mulch (made of Ganba grass, *Andropogon gayanus* Kunth var. *gayanus*) in five rates (0, 2, 4, 6, and 8 t ha^{-1}). Plant height and the number of leaves per plant were maximized at 8 t ha^{-1} rate, while dry stover yield, the weight of grains per cob and grain yield per ha peaked at 6 t ha^{-1} rate. Iyagba et al. (2012) determined the effects of rumenbase organic mulch (0, 20 40, 60, and 80 t ha^{-1}) on weed control and maize performance. Results showed that 40 t ha^{-1} could effectively control weeds and enhance maize yield. Kara and Atar (2013) studied the effects of mulch practices (a control–unmulched treatment, a plastic mulch treatment, and a straw mulch treatment) on fresh ear yield and some yield-related traits of sweet maize according to three sowing dates: 1 April, 15 April, and 1 May. The plastic mulch practice showed the best result. Zamir et al. (2013) evaluate the effect of different sowing techniques (ridge sowing, ridge sowing alternate double sided, bed sowing, furrow sowing and flat sowing) and mulches (maize pith, wheat straw, and rice straw) on growth and yield attributes of maize. Among the mulch treatments, wheat straw mulch performed better and gave higher grain yield (6.21 t ha^{-1}). Khan et al. (2014) evaluated the impact of tillage practices and mulching (wheat mulch and barseem mulch) on the yield of maize crop under semi-arid environment. The combination of wheat straw mulch and mould board plough fallowed by rotavator was recommended. Rajput et al. (2014) studied the effect of dust mulch, green weed mulch, Kans grass (*Saccharum* spontaneum L.) mulch, legume mulch, paddy straw mulch, Subabul (*Leucaena leucocephala* (Lam.) de Wit) mulch and wheat straw mulch (6 t ha^{-1}) on maize under Guava (*Psidium* guajava L.) based Agri-Horti System. The highest yield was obtained with applying paddy straw mulch. Legume mulch gave the highest Benefit/Cost ratio of maize. Yaseen et al. (2014) studied the effect of deficit irrigation (irrigation depth 558.8 and 711.2 mm) and mulch levels (no mulch and 15 t ha^{-1} wheat straw mulch) on soil physical properties, growth and the yield of maize crop. Results showed that maximum increase in plant height (11.39%), biological yield (29.56%), and grain yield (35.5%) was observed with treatment combination of irrigation depth 711.2 mm and wheat straw mulch. Zamir et al. (2014) studied the quantitative and qualitative response of maize to irrigation levels and organic mulches (maize straw and grass clippings). Results showed that maize stalk mulch applied with seven irrigations enhanced crop growth and yield, improved quality content of maize grains and soil physical conditions. Lin et al. (2015) studied the effects of mulching with Caragana powder and plastic film on maize yield. They recommended whole field surface single film mulching planting and due to the lower maize yield, Caragana powder was rejected.

In this study, the effect of position of rice husk as a mulch inserted into soil by a mulch planter machine on maize crop was investigated.

Materials and methods

A suitable piece of land was chosen in a farm of Shahrekord University (32°21'26"N, 50°49'34"E). Shahrekord is a temperate and cold region with dry and warm summer. Its average annual precipitation is 325 mm (Chaharmahal Va Bakhtiari Meteorological Administration, 2015). Soil properties of the farm are shown in Table 1. The farm was fallow and did not have previous crop. Six months before planting, the farm was plowed by a moldboard plow.

Table 1. Some physical and chemical properties of soil of the farm (0-30 cm depth)

Character	Value
Texture	Silty clay loam (clay 38.77, silt 42.86 and sand 18.37 %)
Gravel percentage	Fine: 4%, medium: 20% and without coarse gravel
Soil structure	Type: granule, size: fine, aggregate stability class: 1-3
$CaCO_3$ (%)	26.5
Organic carbon (%)	0.61146
pH	7.18
EC (dS m^{-1})	0.41235

Mulches (rice husk) were inserted into soil with a mulch planter constructed by Sakenian Dehkordi (2007). This mulch planter acts as a no-till device. Therefore, soil preparation was not necessary. During process of planting, mulch was simultaneously placed along row and was covered with soil. Corn seeds were planted in ridges manually because of increasing precision of seeds depth and distance. Planting mulch is shown in Figure 1. The drop of rice husk from the mulch planter and 2.

Figure 1. The drop of rice husk from the mulch planter

Figure 2. Mulch injection into soil by the machine

Three factors were analyzed:

A= the mulch (rice husk) in three levels:

A_1= no mulch

A_2= 200 g mulch per a meter of length (2.67 t ha^{-1})

A_3= 300 g mulch per a meter of length (4 t ha^{-1})

B= planting depth of seeds in two levels:

B_1= 4 cm under soil surface

B_2= 6 cm under soil surface

C= mulch placement in two levels:

C_1= lateral part of row

C_2= sub row (Figure 3)

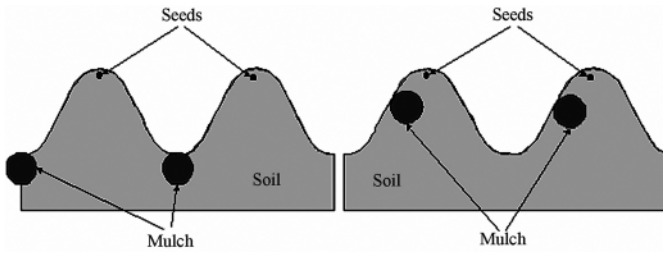

Figure 3. The location of mulch and seed on furrow

Therefore, 12 treatments were applied in four repeats and 48 plots in the experiment. Eighteen seeds were planted in each plot with irrigation every six days. Row distance was 75 cm. Fertilizer was not used. Experiment was performed as complete randomized blocks design. All crops in each plot were harvested and following indices were measured:

ED = ear diameter (cm)

EL = ear length (cm)

ES = ear sheath weight (gram)

EW = ear weight (gram)

HGR = height growth rate (cm per day)

SNE= seed numbers in each ear

PH = plant height (cm)

Data were measured, evaluated and analyzed in suitable time. SPSS software was used for statistical analysis. Interaction effect was calculated using Duncan test.

Results and discussion

Analysis of variance of indexes is given in Table 2.

Table 2. Analysis of variance of studied variables

Sources	*df*	*F*-value						
		Plant height	Ear weight	Ear length	Ear diameter	Ear sheath weight	Height growth rate	Seed numbers in each ear
A	2	2.326	0.146	0.338	0.086	0.314	0.900	2.128
B	1	0.845	0.515	2.371	0.019	0.016	2.073	9.524*
C	1	9.845*	0.103	0.101	0.007	0.009	9.803*	4.543*
A × B	2	0.887	0.822	0.949	0.331	1.556	0.714	2.478
A × C	2	0.271	0.901	0.510	1.759	1.791	0.007	0.647
B × C	1	0.017	0.234	1.190	1.249	0.140	0.911	5.112*
A×B×C	2	4.593*	0.531	0.038	0.135	2.958	3.850*	0.186

* $P<0.05$

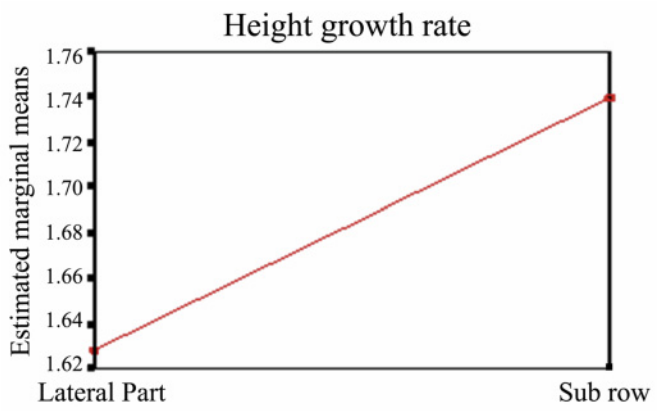

Figure 4. Main effect of mulch placement on the index of height growth rate

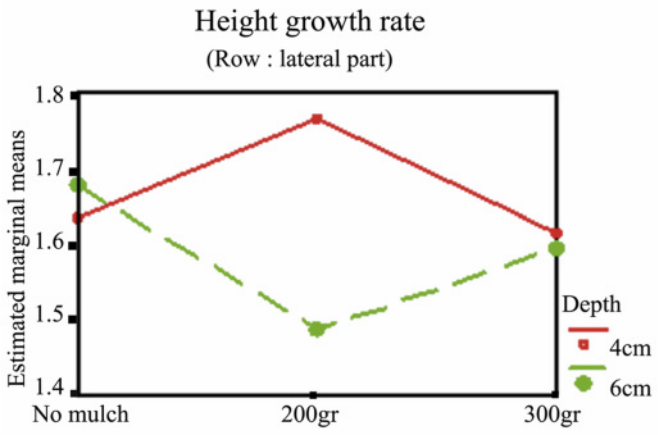

Figure 5. Interaction of mulch amount × depth × mulch placement (lateral part of row) on the index of height growth rate

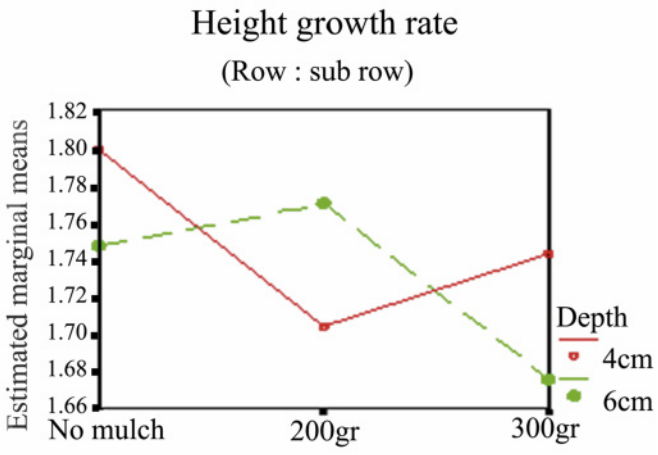

Figure 6. Interaction of mulch amount× depth × mulch placement (sub row) on the index of height growth rate

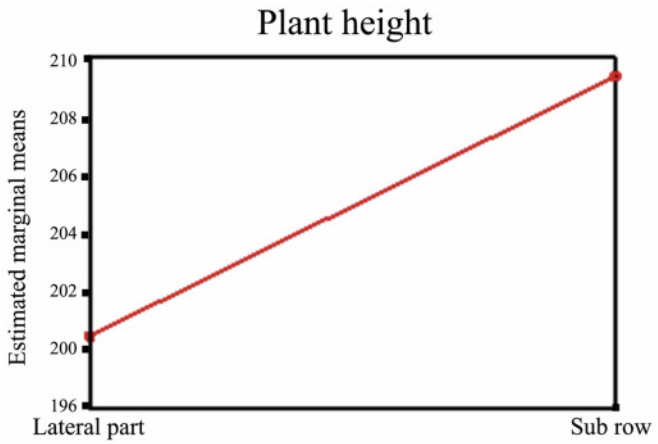

Figure 7. Main effect of mulch placement in row on the index of plant height

Ear diameter (ED), Ear length (EL), Ear sheath weight (ES) and Ear weight (EW)

No significant difference was beheld in main and interaction effects. Mulch can improve moisture content, but more factors except for moisture may require for getting significant difference in these indices. Parwada et al. (2014) reported that conventional tillage + mulch (dried thatching grass, 5 t ha^{-1}) and basin planting + mulch were statistically insignificant ($p<0.05$) on weed density and grain yield of maize. Essoka et al. (2003) did not find significant effect on cob length and cob girth by applying rice husk. Although Anikwe (2000) with rice husk dust (4.5 t ha^{-1}), Chukwu (2001) with unburnt rice husk (50 t ha^{-1}) and partially burnt rice husk (12.5 t ha^{-1}), Essoka et al. (2003) with rice husk (50 t ha^{-1}), and Njoku et al. (2012) with rice husk dust (20 t ha^{-1}) improved maize yield. Therefore, it seems that more mulch (greater than 4 t ha^{-1}) may affect some indexes.

Average of height growth rate (HGR)

Average of height growth rate was measured in centimeter per day and night. There was significant difference in the main effect of mulch placement and in the interaction of mulch amount × depth × mulch placement. These differences are shown in Figures 4, 5 and 6. Status is better in mulch placement of sub row. Moisture absorption in the sub row is higher because of plenty water during irrigation in furrow. It can help to save much moisture in the mulches. This moisture gradually is consumed by plant (especially for a mature plant).

In the interaction of mulch amounts, 200 g is better than 300 g in lateral part of row and status of no-mulch is better in the sub row (at depth 4 cm). Saved moisture in the lateral part is more available for plant rather than sub row, especially at first stages of plant growth. It probably caused no-mulch state became better in the sub row state and 200 g in the lateral part.

Plant height (PH)

Plant height status is similar to HGR condition. There is a significant difference in the main effect of mulch placement and in the interaction of mulch amount × depth × mulch placement. These differences are given in Figures 7, 8 and 9. Other compared conditions lacked significant difference in plant height. Anikwe (2000) reported that 4.5 t ha^{-1} rice husk dust had positive effect on plant height.

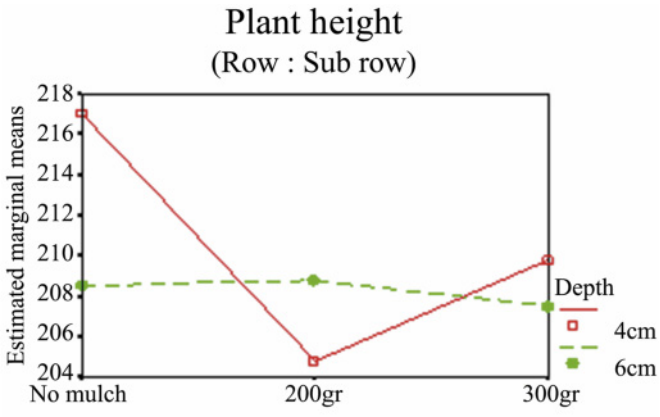

Figure 8. Interaction effect of mulch amount × depth × mulch placement (sub row) on the index of plant height

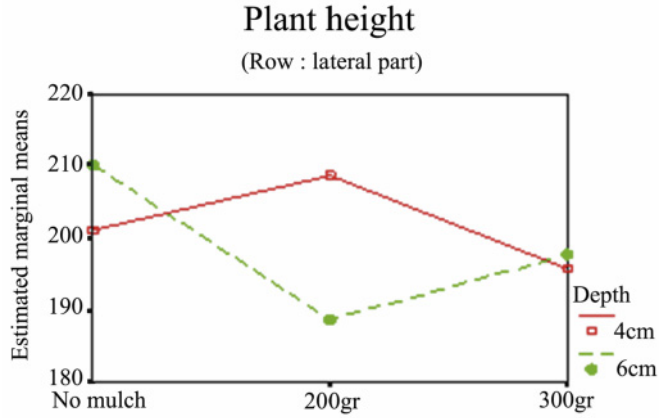

Figure 9. Interaction of mulch amount × depth × mulch placement (lateral part of row) on the index of plant height

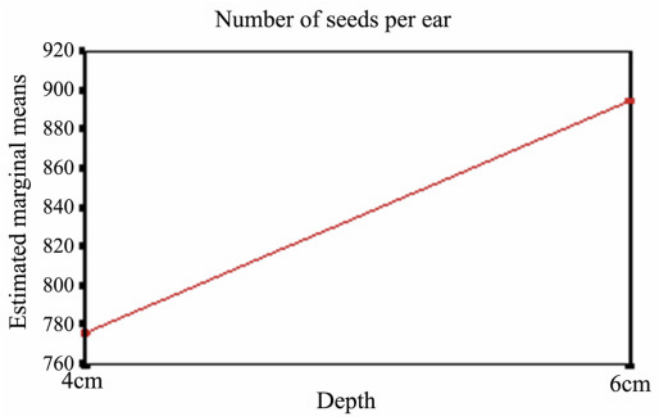

Figure 10. Main effect of depth on the index of seed numbers in each ear

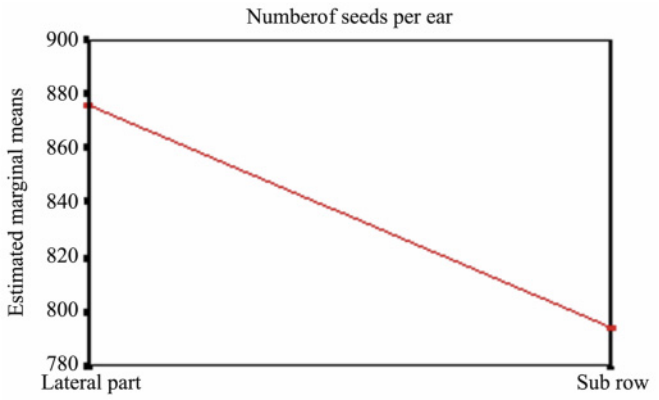

Figure 11. Main effect of mulch placement (row) on the index of seed numbers in each ear

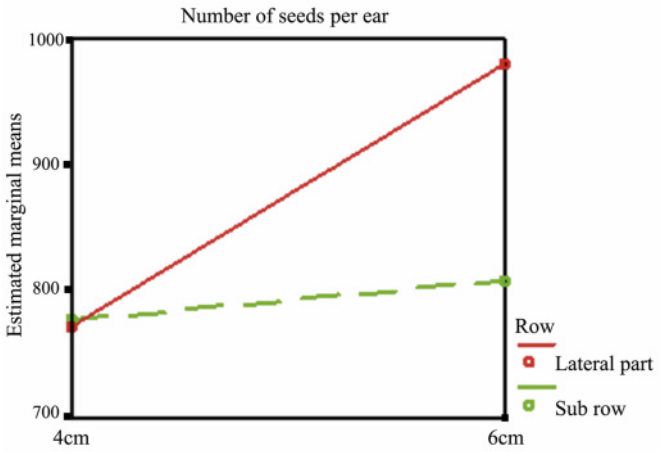

Figure 12. Interaction of depth × mulch placement (row) on the index of seed numbers in each ear

Seed numbers in each ear (SNE)

There was a significant difference in the main factors of planting depth and mulch placement in row and in the interaction of depth × mulch placement. These results are available in Figures 10, 11 and 12. In others, there was no significant difference. Depth of 6 cm and mulch placement in the lateral part were the most effective among other indices.

Plant at depth of 6 cm had more moisture than at 4 cm. It may help to increase SNE. The effect of lateral part was mentioned in the HGR section.

Lin et al. (2015) did not find significant effect on the number of column per maize ear by mulching with Caragana powder and plastic film but the number of kernels per column in one year (2013) had significant difference.

Conclusions

Planting maize in 6 cm depth and dropping 300 g mulch (rice husk) per a meter of length along the lateral part of row resulted

in better conditions. It had significant effect on the indices of plant height, growth rate and the number of seeds in each ear.

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